Chapter 8

Major Themes in the Future of Solar-Terrestrial Science

Chapters 3 through 7 have presented results from the individual discipline groups participating in the Workshop. Viewed collectively, there are certain common themes which deserve recognition and further discussion.

8.1 The Evolution of the Concept of the Solar-Terrestrial Observatory

The Solar-Terrestrial Observatory (STO) was conceived in the early 1980s as a response of the solar-terrestrial research community to the possibilities of attached payloads on the space station. Three different experimental activities were incorporated into the facility: observations of the sun, observations of the Earth's atmosphere, and apparatus to conduct active electron beam experiments in the ionosphere. Following extended discussion at the Workshop, it appears that panel members believe the STO was less a product of specific, synergistic science requirements than a pragmatic reaction to the possibility of reflying a suite of space shuttle instruments on the space station. There was little debate about the capability of the individual observing instruments to provide important, new information about the sun and the Earth's atmosphere, or that the electron accelerator and plasma diagnostic equipment would well serve the needs of space plasma sciences. The point was made that there is no obvious need for these instruments to be flown on the space station as part of an integrated payload. Thus, the concept of the STO has undergone an evolution which recognizes that the individual science goals of the STO are largely independent. This means that the respective scientific disciplines can evaluate the specific science objectives of the STO within the context of their own set of priorities for achieving adequate space observations capabilities.

8.2 Global Imaging of Earth and Sun

A remarkable product of the workshop was the universal support for developing technology and space-based capabilities for multispectral imaging of the sun and Earth. With respect to the solar-terrestrial relations, a case was made for obtaining simultaneous, long-term, low-resolution, multispectral images of the sun and Earth. Such a dual observation program, it was argued, would provide a sensitive means of measuring radiative input to the Earth, and the Earth response. The value of viewing Earth in terms of disk averaged measures of spectral radiance was thought by some members to be sufficiently high to justify further, in-depth study by groups of experts concerned with solar-terrestrial relations.

Other concepts of remote imaging of Earth were proposed. The capability to image global atmospheric, ionospheric, and magnetospheric phenomena was thought to hold considerable promise for understanding global processes. Specific phenomena to be studied in this way included gravity waves in the mesosphere, the dynamics of the plasmasphere, simultaneous views of both auroral ovals, and the flow field of high latitude plasma convection.

8.3 Missions for Data Analysis

All groups of the workshop expressed a desire to develop a means for focusing research activities on data acquired from past space missions. In addition to the practical difficulties associated with retrieving old data from archives, the Workshop members felt that NASA, as an institution, is not inclined to give value to such non-space flight activities. However, the members clearly believe that there is much to be learned from revisiting archived and unprocessed data. In particular, the emergence of powerful processors and the availability of unifying theoretical models makes it likely that important relationships of solar-terrestrial science can be discovered from already existing data sets.

In order to give such analysis activities a higher standing, it was proposed that special data

analysis activities be solicited and managed along the lines of regular satellite missions; i.e., that there be an Announcement of Opportunity, proposals submitted, and peer evaluation. Investigators could compete for participation in the projects and budget time and resources in a manner consistent with what is done with actual flight projects. In addition, once underway there should be a responsible NASA field center with a staff which would include a project manager, supporting experts, and supporting facilities. In this way selected investigators could work as a team to try to resolve specific questions judged (in advance) to be both meritorious and, with some finite probability, soluble with a given data set.

Further study of this concept is clearly warranted. It may well be that it can apply in some sense to future solar-terrestrial missions where broader participation than just the originally selected flight team is justified on the basis of the growth of capability and needs in the overall science community.

8.4 New Space Missions

Each discipline has proposed its own ideas about possible future space missions. In the relatively short time available for the Workshop, little effort has been spent to explore the commonalities of the proposed missions or to determine any realistic priorities among the large number suggested. Nevertheless, there is an important point underlying the presentations of need for new missions: without new data from space observations and experiments, solar-terrestrial sciences will increasingly run the risk of having theory and modeling outpace fundamental knowledge of the solar-terrestrial system. This is an uncomfortable state of affairs which represents pendulum-like oscillation from too little theoretical activity to the point where there may be too little real information to discern the alternatives inevitably offered by theoretical analysis.

Associated with this problem is that of having to decide when enough is known about a given physical process or environment. Scientific observations can be made with increasing spatial, spectral and temporal resolution if sufficient funds are made available. How can one decide when the scientific return from a field has reached the point where the costs outweigh the potential gains? How can one value that which is not known?

In the case of solar-terrestrial science, the desire has been to identify and model general or global processes on the sun and Earth. As long as new experiments continue to provide data which conflicts substantially with theoretical predictions, and as long as we lack fundamental information known from other fields to be of great importance to understanding complex situations, there will be justification for supporting new scientific endeavors in this discipline. The long-term value of understanding the sun and the Earth are beyond dispute.

8.5 New Vantage Points for Viewing Earth and Sun

An interesting aspect of the Workshop has been the interest of the members in identifying new vantage points for observing solar and terrestrial phenomena. As discussed in Chapter 6, the Solar Physics group introduced the idea of having a dual viewing spacecraft looking at the Earth and sun from the L1 libration point. The Magnetospheric Science group mentioned the possibility of using the moon as a site for remote imaging of the magnetosphere and for measuring parameters of the magnetospheric tail. These all deserve careful consideration.

Related to this is the need of magnetospheric sciences to make fundamental measurements simultaneously at a number of locations within the tail of the magnetosphere. The current state of affairs with respect to magnetic reconnection in the tail is that present and future experimental data will be inadequate for judging between competing models of the reconnection process. It is thought that an approach similar to that of the ESA Cluster mission will be needed to make progress on this important question.

8.6 International Collaboration

International collaboration was discussed and affirmed as an important ingredient of solar-terrestrial science. While at one time the United States was the clear leader in initiating new flight

programs, this will no longer be the case in the future. The planned ESA SOHO, Ulysses, Cluster and European Polar Platform missions, as well as the Soviet Interball and IKI-Equator missions are visible evidence for a change towards much more balanced (or dominant) international contributions. In order to assure that the US solar-terrestrial community has access to the data from these projects, it is important that the US stimulate collaboration among the international institutions, as it has in the past. Members of the Workshop heard that some aspects of the international relations are of concern to the international partners, largely because of the lack of action towards the development of a formal means of establishing scientific liaison at the space agency level. Recognizing that many different factors are involved in developing such ties, the Workshop urges that prudent steps be taken to insure that such uncertainties do not jeopardize the position or possibilities of US scientists to participate in international solar-terrestrial science ventures.

8.7 Explorer-Class Satellites

There is a clear need by all disciplines for using Explorer-class satellites to achieve important scientific goals in the future beyond the current missions now being planned. Without such flexible platforms, the vitality of the disciplines will be seriously eroded.

8.8 Space Shuttle Missions

According to information given to the Workshop, only two shuttle missions remain that have important experiments associated with the Space Physics Division. These are the ATLAS-1 mission with a reflight of some Spacelab-1 experiments, and the Tethered Satellite-1 mission, with its complement of US and Italian experiments designed to measure electrodynamics associated with a conducting tether and satellite system. It is now the policy of OSSA to assign future shuttle missions, at least through 1994, to other divisions and principally the Materials and Life Sciences Divisions.

The Workshop was of the opinion that this represents an important loss to all of the disciplines in solar-terrestrial science and that the Space Physics Division should continue to press the issue of acquiring new missions in support of the science programs of the divisions. In particular, Space Plasma Sciences has been badly damaged by this decision since its experiments make heavy use of the high power afforded by the shuttle and the crew resources. Other disciplines had their examples of valid need for the shuttle.

The Workshop urges the Space Physics Division to continue to prepare its science and programmatic arguments for shuttle missions for the 1991-1994 period, recognizing that there may be significant changes in the shuttle manifest over the next several years. Furthermore, the Division should look towards the future when the extended-duration Orbiter will be available for enhanced science missions.

As a group, it is also fair to mention that Workshop participants who have participated in shuttle science missions are appalled at the high costs of using this vehicle. In the long run, and if these costs continue to escalate as they have in the past 5 years, it may well be that the expense of using the shuttle will prevent its use as a scientific platform. NASA should make every possible attempt to resolve this serious problem.

8.9 Space Station and Other Astronaut-Associated Platforms

Attached payloads on the space station will be important to solar-terrestrial sciences. For solar physics, the space station represents a unique means for making long-term, highly calibrated measurements of solar irradiance. The opportunity to exchange detectors frequently is an important aspect of this work.

Space Plasma Science was also able to make strong claim to space station resources for its program of active plasma experiments. The combination of frequent transportation, local crew support, high electrical power, substantial instrument areas, and the possibility of having a large baseline between active sources and diagnostic instruments was judged to be of great importance.

It should be noted, however, that there was considerable concern about the possibility of

instrument contamination from the space station. In addition, the low inclination orbit rules out many science possibilities for ionospheric and magnetospheric investigations on the manned base. The occasionally visited polar platform, however, was thought to provide important opportunities for these disciplines.

The concept of using externally attached payloads on small, astronaut-tended platforms or pressurized modules received strong support from all disciplines. In making this judgment, the members of the Workshop noted that the projected once per 6 months visitation schedule was adequate for most purposes, and the local environment of such facilities would be, in all probability, less contaminated than that of the permanently manned space station. This arises as a consequence of the less frequent reboost periods, the passive boom stabilization systems, and the smaller overall leak rate of the single pressurized module. Efforts to determine the practicability of using tended stations should be pursued by the Space Physics Division as a less expensive, earlier available platform than the permanently manned space station.

8.10 Theory and Modeling

The members of the Workshop strongly agree with NASA's support for theory and modeling. Such fundamental activities provide important direction to understanding the myriad of processes acting in the solar-terrestrial environment and help guide new experimental programs. Ultimately, most experimental knowledge gained from space observations and experiments should be understood within the framework of fundamental physics and chemistry. At the present time, the disciplines are far from such a state of unified understanding. Continued involvement of individuals and groups who deal with theoretical issues and computer modeling, along with those who deal with analysis of data and those who make space observations and experiments, should be an important part of the balance of the solar-terrestrial research program.

8.11 New Instrument Development

The Workshop notes that the Space Physics Division currently has no ongoing budget line for the development of new instruments. Such funds have proven valuable to investigations supported in other Divisions and members of the Workshop give their strong support to the Division Director in his attempts to create such a program.